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CONCERNING THE CREATION OF A SHORT  
DICTIONARY OF FORECASTING TERMS

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Foreign Technology Division  
Wright-Patterson Air Force Base, Ohio

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# U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	<b><i>А а</i></b>	A, a	Р р	<b><i>Р р</i></b>	R, r
Б б	<b><i>Б б</i></b>	B, b	С с	<b><i>С с</i></b>	S, s
В в	<b><i>В в</i></b>	V, v	Т т	<b><i>Т т</i></b>	T, t
Г г	<b><i>Г г</i></b>	G, g	У у	<b><i>У у</i></b>	U, u
Д д	<b><i>Д д</i></b>	D, d	Ф ф	<b><i>Ф ф</i></b>	F, f
Е е	<b><i>Е е</i></b>	Ye, ye; E, e*	Х х	<b><i>Х х</i></b>	Kh, kh
Ж ж	<b><i>Ж ж</i></b>	Zh, zh	Ц ц	<b><i>Ц ц</i></b>	Ts, ts
З з	<b><i>З з</i></b>	Z, z	Ч ч	<b><i>Ч ч</i></b>	Ch, ch
И и	<b><i>И и</i></b>	I, i	Ш ш	<b><i>Ш ш</i></b>	Sh, sh
Й й	<b><i>Й й</i></b>	Y, y	Щ щ	<b><i>Щ щ</i></b>	Shch, shch
К к	<b><i>К к</i></b>	K, k	Ъ ъ	<b><i>Ъ ъ</i></b>	"
Л л	<b><i>Л л</i></b>	L, l	Ы ы	<b><i>Ы ы</i></b>	Y, y
М м	<b><i>М м</i></b>	M, m	Ь ь	<b><i>Ь ь</i></b>	'
Н н	<b><i>Н н</i></b>	N, n	Э э	<b><i>Э э</i></b>	E, e
О о	<b><i>О о</i></b>	O, o	Ю ю	<b><i>Ю ю</i></b>	Yu, yu
П п	<b><i>П п</i></b>	P, p	Я я	<b><i>Я я</i></b>	Ya, ya

\*ye initially, after vowels, and after Ъ, ь; e elsewhere.  
 When written as ё in Russian, transliterate as yë or ë.  
 The use of diacritical marks is preferred, but such marks  
 may be omitted when expediency dictates.

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 merged into this translation were extracted  
 from the best quality copy available.

# RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English
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sin	sin
-----	-----

cos	cos
-----	-----

tg	tan
----	-----

ctg	cot
-----	-----

sec	sec
-----	-----

cosec	csc
-------	-----

sh	sinh
----	------

ch	cosh
----	------

th	tanh
----	------

cth	coth
-----	------

sch	sech
-----	------

csch	csch
------	------

arc sin	$\sin^{-1}$
---------	-------------

arc cos	$\cos^{-1}$
---------	-------------

arc tg	$\tan^{-1}$
--------	-------------

arc ctg	$\cot^{-1}$
---------	-------------

arc sec	$\sec^{-1}$
---------	-------------

arc cosec	$\csc^{-1}$
-----------	-------------

arc sh	$\sinh^{-1}$
--------	--------------

arc ch	$\cosh^{-1}$
--------	--------------

arc th	$\tanh^{-1}$
--------	--------------

arc cth	$\coth^{-1}$
---------	--------------

arc sch	$\operatorname{sech}^{-1}$
---------	----------------------------

arc csch	$\operatorname{csch}^{-1}$
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rot	curl
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lg	log
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THE THEORY AND PRACTICE OF FORECASTING THE DEVELOPMENT OF  
SCIENCE AND TECHNOLOGY IN MEMBER COUNTRIES OF  
COMECON

Appendix I: V. Kaspin, V. Lisichkin (USSR)

Concerning the Creation of a Short Dictionary  
of Forecasting Terms

The wide development of theoretical and practical forecasting work both in the Soviet Union and abroad is attracting scholars and specialists of the most disparate branches of science and technology to studies in this field. The rapid growth in the number of forecasting studies and the wide range of the ways in which these studies are conducted and applied have made the development of a coherent forecasting terminology imperative. The creation of its own conceptual apparatus is one of the most important means for establishing forecasting as a science. The terminological incoherence of forecasting studies and the absence of a single system of concepts and concept classifications significantly retards the development of forecasting. In this connection, on the basis of accumulated experience it is expedient to construct the bases for a conceptual apparatus for forecasting in the form of a dictionary of terms. The basic purpose for creating this dictionary is to regularize and define more precisely the system of forecasting concepts. The removal of ambiguity from the terms in use and the establishment of a connection between the existing categories will permit an increase in the chances for success of scientific forecasting studies and of their practical application. Broadened classification and explication

of the basic concepts ensures the adaptation of the conceptual apparatus for the effective coordination of forecasting work in various fields of knowledge.

All terms in the dictionary are divided into three classes:

general terms;

terms relating to the object of the forecast;

terms relating to the methods of forecasting.

In choosing the terms, both forecasting concepts and concepts from allied branches of knowledge (mathematics, cybernetics, philosophy, etc.) were used. However, principal attention is devoted to the specific terms of forecasting. The present work offers itself as working material for discussion and further refinement.

### A Short Dictionary of Forecasting Terms

#### General Terms

The Adequacy of Numerical Confirmation - numerical confirmation is adequate only when its truth value is invariant relative to the admissible scale conversions of each of its numerical representations (i.e., each of its representing functions expresses the result of a measurement).

Algorithm - the extended description of the structure and sequence of operations of the functioning of a certain system or of the solution of some problem.

Antagonistic Games (zero sum games) - games in which the sum of the gains of the players in each situation is equal to zero.

Vector - a series or column of values or of variable quantities, qualitative or quantitative, either arranged in a fixed order or not.

Verification - a specialized procedure for evaluating the reliability of the forecasts which have been made. Verification as a method of checking out prognostic knowledge does not answer the question of whether the forecast is true or false. However, with the help of verification the forecaster is enabled to evaluate the reliability of forecasts with a reliability sufficiently high for practical recommendations.

Direct Verification - defining the parameter on the basis of another method of forecasting.

Indirect Verification - assumes the corroboration of the forecast.

Consequent Verification - obtaining the value of the forecast being verified by drawing logical or mathematical conclusions from the results of already known forecasts.

Duplicate Verification - determining the value of the forecast being verified from another forecast, received as an answer to the same question, formed by a different means.

Verification by the "Devil's Advocate" Method - verification is achieved by means of opponents ("Devil's Advocates") who have the task of adducing arguments and conclusions to



show that the forecast being verified is impracticable or unrealizable. The forecast being verified is considered reliable if the forecaster proves that all arguments of the "Devil's Advocates" are unsound.

Inverse Verification - verification is achieved by means of extrapolation to the left of the dynamic forecasting series or by inverse extrapolation. Comparing the values of the forecasts (obtained by inverse extrapolation) with the real values of the object in the same retrospective years permits a conclusion to be drawn about the verification of the forecasts obtained.

Verification by the Minimization of Systematic Errors - checking the inventory of the sources of systematic errors in the process of producing forecasts. For the realization of the present method the forecaster must have a classification of the sources of errors at his disposal.

Sampling: a certain aggregate of sampled values (i.e. values of random magnitude) from a general aggregate, obtained as the results of separate experiments.

General Aggregate - all possible values of random magnitude which can be fixed in the sequence of experiments under a determined complex of conditions.

Determinism - the acknowledgement of general objective conformity to law and of the cause of the conditionality of social and natural phenomena.

Discreditation - the replacement of a continuous quantity by a disruptive one in time (by a grid function). To discredit

a function means to exclude from consideration a great many of its values in the course of some set intervals of time.

The Forecasting Task - the formalization of exactly what must be forecasted, with what accuracy, at what time in advance and under what conditions.

A Game - a model of a conflict situation, a situation in which the participants have conflicting interests and different means at their disposal to achieve their goals.

Complete Information Games - all participants have complete information about the situation laid down in the game at each moment of time.

Incomplete Information Game - the participants have incomplete information about the positions laid down in the game.

Measurement - (1) A cognitive process by which a relation is determined between one quantity (being measured) and another uniform quantity (taken as the unit of measurement); the number expressing such a relationship is called the numerical value of the measured quantity, i.e., the measurement of the quantity signifies the finding of its numerical value by means of the unit of measurement. (2) A variable, characterizing the object being studied; the number of measurements of a given object is the number of variables used to describe it.

Direct Measurement - its result is obtained directly from measurement of a quantity.

**Indirect Measurement** - the measurement of a quantity whose numerical value is obtained on the basis of direct measurements of other quantities bound with that which is being measured by a mathematically fixed expressed dependency.

**Isomorphism** - a relationship between objects, expressing in some sense the identity of their structure; isomorphism may be expressed as a mutual-identity correspondence between a determined group of properties or relationships; in such cases, we speak of the invariance of the properties of isomorphic systems. If the correspondence referred to in the definition of isomorphism between the elements of the sets is identical only in one aspect, then this relation is called a homomorphic one.

**Information File** - the aggregate of original data, characterizing the object of the forecast and incorporated into the determined system.

**Investigative/Scientific-Technical Forecasting** - formulating forecasts of the objectively existing tendencies of the development of science and technology under fixed conditions regardless of the goals, wishes or demands of social groups; a real investigative forecast is a picture of the condition of science and technology at a given future moment of time.

**Error Sources of Forecasts** - factors influencing reliability. The sources of irregular forecasting errors are random disturbances and rare, unforeseen events. The sources of regular errors are: a method whose basis is inadequate for the object, or the breaking of its application procedure; insufficient skill in work or lack of knowledge of the peculiarities of the method; unreliability, incompleteness, or failure to discount the original data, etc.

**Quantization** - transforming a certain quantity with a continuous value scale into a quantity having a discrete value scale; the values of a variable making up a discrete scale of a quantized quantity are called quantization levels.

**Class** - an aggregate of objects, phenomena, or conditions, united on the basis of an identification goal or other common trait.

**Code** - 1) the expression of the values of a continuous coded quantity as numbers (binary, binomial and non-binomial (number of symbols)); 2) the number of symbols is the basis of the code.

**Coding** - putting information into code. The goal of coding is, as a rule, the matching of the source of information with the communication channel: i.e. the fulfilling of certain conditions dependent upon the properties of the information source and of the communication channel.

**Correlation** - the simplest, but most practically important aspect of statistical or probability relations between random events or quantities which can be expressed by a number. Correlation between two random quantities is characterized quantitatively by a coefficient of correlation or by a correlative relation.

**Matrix** - a certain rectangular table of variable quantities.

**Matrix Games** - antagonistic games in which each player has a finite number of strategies.

**Method of Forecasting** - a technique of practical and theoretical actions of a forecaster, directed toward producing forecasts for an object. Each method must have a theoretical foundation--an aggregate, systematized (in a definite way) of special knowledge (theory, hypothesis, empirical model, etc.). Certain methods of obtaining forecasts are suitable for all branches of knowledge, because they relate to the general scientific method of forecasting (logical and heuristical methods of forecasting). Others have application in separate branches of science, technology, economics, etc. as they relate to inter-scientific methods of forecasting (model building, statistical, patent methods, etc.). Particular scientific methods used within particular branches of knowledge (hydraulic, sociological, etc.) comprise the third group.

**Forecasting Principles** - an aggregate of special rules and particular procedures by which one must be guided when solving various problems in producing forecasts.

**Methodology of Forecasting** - an area of knowledge which studies general and specific methods of producing forecasts, and also the methods of organizing forecast studies; the general methodological principles of forecasting are grounded in dialectical and historical materialism. The science of forecasting (prognostics) develops special methodological principles. The object of its study is the process of the production of forecasts in all its entirety and complexity--i.e., the entire scientific-cognitive pursuit of forecasting in the organic unity of its component parts and social requirements.

**Minimization of Structure** - transforming the structure of a definite system, so as to reduce the number of component elements without altering the algorithm of its functioning.

Model - two systems of objects A and B are called models of each other (or are said to be modelling one another) if it is possible to set up a homomorphic representation of system A in a certain system  $A^1$ , and a homomorphic representation of system B in a certain system  $B^1$ , so that  $A^1$  and  $B^1$  will be isomorphic. The relation of "being models" thus fixed is reflexive, symmetrical and transitive, i.e. it is an equivalence relation. On the content plane, a model is a mentally represented or materially realized system, which, representing or reproducing the object being studied, is able to substitute for it, so that the study of it (the model) gives us new information about the object.

Modelling - studies in models or in real units with the use of the methods of similarity theory while setting up and conducting experiments. Stages in the creation of a mathematical model of a process are: the creation of a content description--a description in words, containing information about the nature of the qualitative and quantitative characteristics of element phenomena, the degree and character of the interaction of the elements, the position and significance of each element phenomenon in the general process. A content description is a concentration of basic knowledge known to us about the composition and functioning of all the elements of the object under consideration; the creation of a formalized scheme--the establishment of a set of characteristics, parameters, diagnostic parameters and primary conditions.

Reliability of the System - an aggregate of system properties, determining its degree of suitability for its designated use and involving the possibility of the appearance of carelessness and mistakes in work.

**Normative Scientific-Technical Forecasting** - formulating forecasts of those directions of the development of science and technology which are to permit the solution of problems for the attainment of definite interests, demands or goals, proposed by this or that social group.

**Image** - the designation, singled out for a suitable purpose, of a connected area in an attribute field (in which area many objects or phenomena are reflected).

**The Object** - that which is given in cognition or to which the cognitive activity of the subject is directed.

**The Object of Scientific-Technical Forecasting** - all phenomena and processes relating to the development of science and technology; the content aspects of scientific research and work; organized forms, human, material, financial resources, etc.

**Parameter (of an object, of a system)** - a quantity, characterizing some property of an object, or characterizing a system.

**Paired Congruences** - A system  $X - N = \langle B, P \rangle$  where  $B$  is a non-empty finite set of objects or symbols, and  $P$  is a numerical function  $B \times B$  such that for all  $a$  and  $b$  from  $B$ ,  $0 < P_{ab} < 1$ ,  $P_{ab} + P_{ba} = 1$ ,  $P_{aa} = 0.5$ . Paired congruences (the Bradley-Terry, Luce System) occur only when the multiplication condition is fulfilled, i.e. when, for all  $a, b, c$  of  $B$

$$\left( \frac{P_{ab}}{P_{ba}} \right) \left( \frac{P_{bc}}{P_{cb}} \right) = \left( \frac{P_{ac}}{P_{ca}} \right)$$

**Variables** - are magnitudes which take on various values in the process of their change. Free "entry" of variables into the terms of scientific content theories and into formulas is a free variable. In such cases, when a free variable is understood as a set of values constant (fixed) within the limit of some context (for example, the derivation of a given aggregate of formulas), such values are ordinarily called parameters relating to the given context. Thus, it is said that  $X_1, \dots, X_n$  has a conditional interpretation in the given context  $\sin X$ , with the solution of  $X$  as a parameter.

**Perspective Planning** - the drawing up and the organizing for realization of development plans for agriculture and its separate branches and industries, planned out for a series of years (5, 7, 10, 20).

**Threshold Value** - the threshold of a magnitude is the value of the magnitude in the input of a certain arrangement, block, or algorithm, whose attainment will cause an irregular alteration of the latter's condition.

**Predicting** (in mathematics) - an exact or approximate determination of the next value of a function with respect to a certain data aggregate, dependent upon its previous values.

**The Principle of the Verification of Predictions** - a methodological requirement for determining the reliability of a forecast by a correlation with the values of forecasts of the same parameter, specially obtained by various methods; corroboration of the value of the forecast produced by reference to the literature, deduction of the forecast of the given parameter from forecasts of other parameters or by some other method.



**The Principle of Completeness** - a methodological requirement for the simultaneous working out of forecasts of all parameters of the object in their interrelation and in their entirety. The given principle is realized most fully in the creation of a prognostic system.

**The Principle of Continuity** - working out a series of forecast models of an object at given time intervals on a continuous correction basis whenever new data about scientific and technical achievements is received.

**The Principle of Practical Directive Effort** - the inclusion of the forecasts worked out into the system of initial data to raise the effectiveness of planning and control.

**The Systematic Principle** - a methodological requirement for the synthesis of worked-out forecasts of separate parameters into multivariant forecast models, and for their coordination with the established goals.

**The Principle of the Coordination of Normative and Investigative Forecasts** - the joining and interrelation of normative and investigative forecasts during the working out of forecasts for each object.

**Forecast** - A probability judgment, describing (in terms of some linguistic system) the condition of the object of the forecast at a determined future period of time.

Forecasting - an aspect of man's cognitive activity directed toward the formulation of forecasts concerning the development of an object.

Forecasting Scientific-Technical Progress - the process of determining different variants in the development of science and technology for a fixed future time interval, on the basis of an analysis of their development tendencies and a calculation of social demands and goals.

Forecast Model - a system of interrelated forecasts, characteristics and parameters of an object.

Forecasting Stage - an important part of the process of the production of forecasts by the solution of a certain independent problem characterized by its own specific methods and apparatus.

The most characteristic stages:

setting up the problem - defining the object of the forecast, accurately formulating the purpose and the task of the forecast, defining the degree of accuracy and the lead time;

formulating the object of the forecast in relation to the problem established - the structure of the object is made clear, the existing variables are isolated, their order, hierarchy, and interrelation are established;

a collection of retrospective and current information about the object - information sources are made clear and evaluated according to various criteria (reliability, periodicity, objectivity, etc.), a method of reworking and presenting

information is devised, and the essential dimensions of the information are evaluated;

formalizing the problem - a method for the formalized presentation of information is worked out; there is a formalization of the description of the object of the forecast, and a formalization of the problem itself;

choice of method and working out of the principal algorithm - from the number of variables or known quantities in the conditions of the problem, the most appropriate forecast method is chosen; and the extended principal algorithm corresponding to this method is worked out, and the accuracy of the method is evaluated;

production of the working algorithms on the basis of the main algorithm - the algorithms for separate sub-stages are worked out; they are run through and verified in relation to the retrospective data;

test model building on the basis of retrospective work - the working of the entire prognostic algorithm is verified on the basis of model building with respect to portions of development in the past, and the correction of the main algorithm is carried out;

production of the forecast - the forecast itself is produced and the results distributed;

use of forecast results - the results obtained in the forecasting process are used in accordance with established goals, corrections are made, decisions are made. Sometimes secondary forecasts are produced.

**Forecasting System** - an aggregate of methods, algorithms, programs, mechanical devices and a group of people, functionally joined together to produce a forecast on the basis of the available information and the problem established.

**Prognostics** - a branch of scientific knowledge which studies the ways in which the production of forecasts is controlled by laws.

**Program** - a complete, accurate, detailed description in a certain formal language of the process of processing information, directed towards the solution of the problem established.

**Progress** - an ascending tendency toward development. It is possible to speak of progress in conformity to the system as a whole, its separate elements, its structure, etc.

**Attribute Field** - an  $N$  coordinate field, along the axis of which numerical attribute values are plotted, characterizing the object or phenomenon from the point of view of identification of the problem established.

**Development** - the process of alteration of an object, the process of transition through a series of stages, from appearance to disappearance.

**Image Identification** - a division of cybernetics which develops the theory and principles of the construction of systems which separate complex situations and set classes; together with the development of methods for the isolation of the important general properties of a certain aggregate of signals of methods for the definition according to these properties, to which, of the well-known type (classes) the

signals belong; of methods for the uniting of the incoming signals into a certain number of groups.

Identifying System - contains: a sensing apparatus, which determines the transformation of incoming signals X into a certain set, called the receptor field; a transforming unit which places a certain element of the new field X, called the attribute field, in relation to each element of X, a decision-making unit, which works out, with relation to the elements of the training sequence, the characteristics of each image and which realizes various decision-making rules, i.e. rules for relating each element of the receptor field to one or another image in accordance with the received characteristics.

Magnitude Being Regulated - a magnitude whose value in the system or the object must either be supported by a constant, or which must vary in relation to the control conditions given.

Deciding Function (rules) - the rule of the division of an attribute field into areas, corresponding to different images.

Self-Adjusting Model - a model whose characteristics vary depending upon variations in external influences.

Synthesis of Forecasts - the uniting of forecasts, characteristics and parameters of an object according to given criteria.

Synthesis of a System - working out the control portion of the system--the choice of principles of control, type, plan and parameters.

**System** - a set of interconnected elements, appearing as a definite integral formation.

**System with Relations** - a finite sequence of the type  $I = \langle A, R_1, R_2, \dots, R_n \rangle$  where  $A$  = a non-empty set called the range of the system with relations, and  $R_1, R_2, R_3, \dots, R_n$  are relations in  $A$ . The type of a system with relations is the number of relations in the system and their position. For example, a system with relations  $S$  of the type  $S = \langle m_1, m_2, \dots, m_n \rangle$  signifies a system with  $n$  relations, each with position  $m_i$ .

**System with Similar Relations** - a system with relations all of the same type.

**Isomorphic Systems with Relations** - similar systems with relations  $I = \langle A, R_1, \dots, R_n \rangle$  and  $W = \langle B, S_1, \dots, S_n \rangle$ , for which there exists a one-to-one representation of  $A$  in  $B$ , such that for each  $i = 1, 2, \dots, n$  and for each sequence of elements  $\langle a_i, \dots, a_{m_i} \rangle$  of the elements of  $A$ ,  $R_i(a_i, \dots, a_{m_i})$  takes place when  $W = f(I)$ . In such a case  $W$  is called the isomorphic image of  $I$ .

**Systems with Homomorphic Relations** - isomorphic systems with relations for which a rigid demand of a one-to-one correspondence is made, such that several elements of  $A$  may be represented in one element of  $B$ .

**Numerical System** - a system with relations  $\langle A, R_1, \dots, R_n \rangle$  which has a range  $A$ --a certain set of real numbers. A complete numerical system--a system which has a range  $A$ --is a set of all real numbers.

**Empirical Systems** - systems with relations, the ranges of which are sets of elements, such as weight, feature, condition.

**Statistical Estimations** - functions of the results of observations of a certain random quantity (functions of sampling values).

**Player Strategy** - all possible actions permitted to the player by the rules of the game.

**Structure** - the stable bond, in conformity with the laws, and the interrelation of the parts and elements of the whole, of a system: an exact definition in mathematics is obtained with the help of the concept of isomorphism.

**Thesaurus (handbook)** - a list of semantic associations given in a certain language; a dictionary in which all semantic associations between the words of a language are indicated.

**Tendency** - direction of development. The progressive tendency - the process of going from the simple to the complex, from the lowest to the highest, from less to more complete. Regressive tendency - descending transition from complex to simple, from highest to lowest.

**Theory of Prediction** - a mathematical discipline, the object of which is the construction and study of methods of optimal prediction.

**Theory of Statistical Decisions** - a division of mathematical statistics, which studies the rules of the choice of decisions in conditions of indefiniteness, i.e. in conditions

where the man or the machine choosing this or that course of action does not have full information.

**Technological Progress** - the progress of developing and perfecting technical knowledge and the technology of production in the economy; also, the process of introducing advanced methods and labor procedures to production, introducing scientific/technical discoveries and inventions which raise the productivity of social labor and on this basis increase the output of production at the lowest labor cost.

**Control** - the implementation of actions, chosen from a set of possible ones, on the basis of definite information, directed towards the maintenance or improvement of the object being controlled in correspondence with an existing program or control goal (functioning algorithm).

**Controlling Action** - action upon an object to implement the law of control.

**Control of Operations** - control of the activity of collectives of people, equipped with definite materials and resources, whose activity is directed toward the attainment of a determined goal.

**Background Inventory** - an inventory of the internal peculiarities of the development of the object of forecast and the associated external factors with which the object interacts in its development; the job of the background inventory is divided into three parts: analysis of the background which actively interacts with the object of forecast, i.e., the forecast of the development of the active background; the background report proper; and the introduction of corrections



in the forecast of the object of forecast on the basis of data on background evolution.

**Background** - the external environment surrounding the conditions, and the set of objects and of their associations which define the conditions for the existence or functioning of the object of the forecast.

**Factor** - the moving force of a process being completed or one of its necessary conditions; a mathematical factor is one of the numbers being multiplied (multipliers).

**Formalization** - the refinement of the contents of knowledge by means of the comparison, in a determined way, of objects being studied, or phenomena, and of the processes of a given range of activity with certain material constructs with a relatively stable character, thus permitting the essential and regular features of the objects being examined to be set forth and fixed.

**Logical Formalization** - an exposition, in logical form, of conclusions and evidence. Generally, formalization is refinement of the contents of knowledge with the help of an exposition and fixation of its form. Therefore, formalization approximates content and is not absolutely able to transmit it. Formalization is the transmission of the description of the forecast object into a quantitative form.

**Goal** - in the philosophical sense, is the mental anticipation of the desired results of the activity. Goals arise when there are demands and interests already formed. Social practice is characterized not only by the production of objects of human activity but also by the production of demands, by the existence of contradictions between the qualitatively

rapidly changing and the quantitatively rapidly growing demands of society and the means themselves (possibilities) for the satisfaction of those demands. These contradictions which arise objectively in social practice are reflected in the consciousness of man in the form of tasks or problems under fixed conditions. The set of these conditions determines the entire situation (realization of the goal), by which is meant the realization by man of the non-correspondence between his demands in certain resultative, practical or theoretical actions, and the available items, properties and relations in the real world.

Value - qualities of material objects and of the phenomena of social consciousness, characterizing their significance for society, for a class, for a man.

Numerical Concept Coding - the representation of concepts as numerical codes (numbers) permitting the unambiguous transference of their literal transcription to numerical codes and the unambiguous decoding.

"Black Box" - an object of investigation whose internal structure is either not taken into account or is unknown.

Scale - an ordered set of three elements  $\langle u, w, f \rangle$  where

$u$  = an empirical system with relations

$w$  = a complete numerical system

$f$  = a function which homo- or isomorphically represents  $i$  in subsystem  $w$ .

Absolute Scale - a single scale with accuracy to the point of an identity transformation of the type  $f(x) = x$ . Example: counting the people in a group.

Scale of Relations - a single scale with accuracy to the point of a transformation of similitude of the type  $f(x) = dx$ . Example: a scale of lengths, weights.

Scale of Intervals - a single scale with accuracy to the point of a positive linear transformation of the type  $f(x) = \alpha x + \beta$  ( $\alpha \neq 0$ --a positive real number,  $\beta$  = any real number). Example: a temperature scale.

Scale of differences - a single scale with accuracy to the point of the displacement transformation  $f(x) = x + \beta$  ( $\beta$  = real number).

Scale of order - a single scale with accuracy to the point of any monotonic transformation  $f(x)$  ( $f(x)$  = any monotonically diminishing or increasing function). Example: a scale of mineral hardness; Beaufort scales of wind strength.

Classification Scale - permits any arbitrary transformation  $f[f(x)] = \text{const}$  (for all  $x$  of one class).

Scale of Designation - numbers are used as substitutes for the designations of objects. Example: the numbering of attributes, phenomena, qualities, etc.

Productive Scale - a set of three elements  $\langle w, R, g \rangle$  where  $w = \langle B, f_1, f_2, \dots, f_n \rangle$  is a productive measurement system;  $g$  is a measureable numerical function in  $B$  (or in the direct product  $B \times B$ ),  $R$  is a relation between  $f_1, \dots, f_n$  and  $g$ . Example: for the system  $w = \langle B, m, v \rangle$  of measuring density,  $R$  is defined as  $R \langle m, v, d \rangle$ , if for each  $a$  from  $B$   $(a) = \frac{m(a)}{v(a)}$ . Then the set  $\langle w, R, a \rangle$  is a productive density scale.

**Heuristic Methods** - methods employing certain factors (heuristics) to reduce the search for a solution to a problem, which do not guarantee that it will be found.

**Heuristic Programming** - a type of programming, using specific methods of solving problems for which in general either a criterion for exposition of the application of the method does not exist, or strict criteria were unknown earlier.

**Equivalency** - two assertions are equivalent only when they have the same truth value.

**Entropy** - the measure of indeterminateness of a situation (of a random quantity) with a finite or computed number of outcomes.

**Algorithmic Language** - an aggregate of a set of basic symbols of a system of rules for the devising from these symbols constructs and a system of rules for the unambiguous interpretation of these constructs, permitting the creation of algorithms.

#### Terms Relating to the Forecast Object

**Vector of the Object** - a series or column of significant variables, symbols or factors of an object put in a specific order.

**Temporary Object Characteristics** - data about the character of the alteration or development of the object in time. From this viewpoint, it is possible to distinguish the following types of object:

simply periodic - objects whose conditions repeat accurately over equal time intervals;

periodic - objects having objective periodicity of development with a stable periodic magnitude; exact concurrence of states is not required; fluctuations in some limits of the values of the variables at the same moments of development of the cycle are allowed;

quasi-periodic - objects with a periodic nature of change, but the magnitude of whose period is not stable over time;

aperiodic - objects which do not have a periodic nature of change or development.

Input Quantities - parameters acting upon the studied object which lend themselves to orderly change (not to be confused with noises, which are distinguished from incoming magnitudes by the random nature of the magnitude and of their distribution over time. At best, noises can be measured.

Output Quantities - parameters of the object under consideration which change under the influence of processes evoked by a change in the incoming magnitudes and internal parameters.

Graph Model of an Object - one of the formalized representations of the object. The vertices of the graph model are the incoming magnitudes, characteristics, process parameters, auxiliary parameters, natural system parameters, and defects.

**Defects** - non-correspondence of the values of the natural parameters of the object with earlier established norms.

**Primary Measurement** - a numerical representation of a significant variable, obtained by direct measuring of the object by means of one of the allowed scales. Primary numerical representation is a function which homomorphically maps an empirical system into a numerical system.

**Productive Measurement** - a numerical representation of a significant variable, obtained as a certain function of primary measurements. Productive measurements are constructed on the basis of other numerical representations.

**Informativeness (Shennonovsky) of an Attribute, Factor, Variable** - the amount of information (reduction of entropy) which adds knowledge about the value of the given variable (attribute factor) to information about the object.

**Semantic Information** - thought content, which bears in itself information from the point of view of the transmitter or the receiver.

**Information (Shennonovskv)** - a measure of the reduction in the indeterminateness of choice or of outcome possibilities, created by some kind of communication (the difference of entropies in the description of the forecast object before and after receiving the communication).

**Unity of Quantity of Information (Shennonovsky)** - a quantity of information which is able to maintain an apparatus in two stable states: a unity and a binary digit.

**Range** - a characteristic of the object of the forecast, defining it from the point of view of a number of certain component units. Using such units, it is possible to use a number of significant variables which describe the object:

- sublocal - from 1 to 3 variables;
- local - from 4 to 6 variables;
- superlocal - from 7 to 14 variables;
- subglobal - from 15-30 variables;
- global - from 31-100 variables;
- superglobal - over 100 variables.

**Range of an Object** - the number of significant variables used for the description of the object.

**Minimization** - the process of reducing the gauge of the description of the object.

**Normalization** - reduction of the description of the object or some part of it to a standard invariant form of a certain group of permissible transformations.

**Object of the Forecast** - a process, phenomenon, or event, relative to which one must solve the problem of choosing a forecast method and producing a forecast.

**Parameter** - a characteristic of the forecast object or of the forecasting system, which is taken as a constant in the process of preparing and producing a forecast, and which is changed only from object to object or system to system.

**Parameters for the Functioning of the System** - characteristics of the subprocesses which comprise the basic process of the functioning of the system, permitting the task to be fulfilled for which the system was created.

**Auxiliary Parameters** - magnitudes of subprocesses of characteristics of auxiliary processes which do not participate in the realization of the main process and which are extraneous phenomena (noise, vibration, motor heat).

**Dynamic Parameters** - elements of an aggregate of parameters over which they were established as a control and which contain information about carelessness.

**Natural (Structural) Parameters of the Object** - physical, chemical, electrical or geometrical properties of its components or elements.

**Significant Variable** - any characteristic of an object of the forecast or of the forecasting system which is able to take on different values in time and which can map the state of the forecast object; usually when the term "variable" is used, significant variable is meant.

**Attribute** - one of the significant variables. In the range of the full set of these variables, factors are divided out.

**The Natural Domain of the Object of the Forecast** - the domain of existence of an object, the sphere of being to which the object belongs. According to natural domain, objects are divided into natural objects which reflect phenomena and processes occurring completely in nature or are basically



independent of man; and into social objects--objects of the life and activity of human society, reflecting its material and spiritual development (social, economic, military-political, scientific-technical, etc. objects).

Complexity - a characteristic of an object which defines it from the viewpoint of the relationship of variables.  
Objects are:

internally simple - having only independent internal variables;

internally connected - having links only between pairs of variables;

internally complex - having mutual links between sets of three elements and a great number of variables;

externally simple - having only mutually independent external influences;

externally complex - having mutually connected external influences.

Degree of Determinability - characteristic of an object, defining the nature of the laws of change of the majority of the significant links of its internal variables:

determined objects - objects, all of whose variables change in functional dependence on time or another argument, despite the fact that a part of or all of these functions are unknown;

**stochastic objects** - the overwhelming majority of the variables change randomly over time or in relation to other arguments;

**mixed objects** - objects which are described both by functionally changing and by randomly changing variables.

**Structure** - a set of significant variables or elements together with their manner of coordination and a schedule of their connections.

**Point of the State of the Object** - coordinates of the point corresponding to the position of the object in an N-range of attributes or factors at a fixed moment of time in the past, present or future.

**Trajectory of Object Development** - an N-curve which describes the end of the vector of the object over time in a range of significant variables, attributes or factors of the object.

**Factor** - a generalized observable or unobservable characteristic expressing one of the essential features of the object (of the class of objects) from the point of view of the established forecast problem. By means of division, a factor is in the majority of cases a latent vector of a covariant matrix of attributes.

**Characteristics of a Process** - output parameters, which characterize the basic functions and result of a process, for the realization of which the object has been created.

Entropy of a Set of Probabilities - a measure of how great is the choice from a set of events or how indefinite its outcome is for us. Entropy H is expressed:

$$H = - K \sum_{i=1}^n P_i \log P_i,$$

where K is a certain positive quantity, determining the unit of measurement.

#### Terms Relating to the Methods of Forecasting

Input-Output Analysis - a method of studying the development of an object on the basis of the representation of the dependence between significant variables (output) and influencing factors (input) as a matrix (in particular that of Leontiev-Evans).

Analytic Expert Evaluations - a method of forecasting the qualitative attributes of a scientific-technical object on the basis of their qualification by one of five methods: preference, rank, partial comparison of pairs, full comparison of pairs, study comparison.

Delphi Technique (Delphi Method) - investigation on the basis of sampling of expert opinions about the prospects for development of some object to bring into focus the dominant opinion of the specialists, excluding direct debates, but permitting the experts to periodically evaluate their opinion by taking into account the findings and conclusions of their colleagues.

**Individual Expert Evaluations** - a method of forecasting, which consists in attracting experts to determine the development of the object on the basis of professional experience and intuition.

**Interpolation** - a procedure for finding the values of the function  $y = f(x)$  at points  $x$ , lying between points  $x_j$  (where  $j = 1, \dots, n$ ) if the values of the function  $y_i = f(x_i)$  are known at points  $x_1 < x_2 < \dots < x_n$ . Interpolation is correct when three conditions are fulfilled: the interpolated function must be continuous and analytic, inequalities are pointed out for the concrete type of functions, or their derivatives, determining the application of interpolation to the given function; the function must be sufficiently smooth; i.e., possess a sufficient number of derivatives which are not increasing too fast.

**Graduated Interpolation** - the preservation of the magnitude of a discrete number in the course of a period  $T$  of the study of the discrete numbers.

**Linear Interpolation** - the vertices of the discrete numbers are connected by segments of straight lines.

**Interpolation Error** - the difference between the instantaneous values of the regenerated and output signals at one and the same moment of time; they are usually defined by the average quadratic values of this error.

**Covariance of Two Variables  $y$  and  $x$**  - the index of their combined variation.

$$\sigma_{xy} = \int [x - M(x)][y - M(y)].$$

**Correlational Analysis** - a method of mathematical statistics studying the correlative connections between phenomena when the following conditions are fulfilled:

random values must be taken as sampling of a two-dimensional general set with a normal distribution law;

the expected degree of error is equal to zero:  $\Sigma(\hat{u}) = 0$ ;

separate observations are stochastically independent;

covariance between errors connected with various values of the variable is equal to zero;

error variances connected with different values of the dependent variable are equal among themselves;

covariance between the error and each of the independent variables is equal to 0.

the analytic expression approximating the empirical curve must be linear relative to its parameters;

the observation of independent variables is carried out without errors.

**Correlational Connections** - connections of two or more random values  $x$  and  $y$ , existing if the mathematical expectation for one of them changes subject to a change in the other:  $y = a + bx$ .

**Latent Analysis** - a method for the exposure of hidden factors and links influencing the significant variables of the forecast object. This method is accomplished by a mathematical-statistical analysis of initial data.

**Matrix Method of Forecasting** - a method of evaluating the prospects of different trends of NIR and OKR in planning the development of a branch of technology, permitting:

the production of an analysis of different variants of NIR and OKR projects and the rating of these according to their importance for the achievement of the established goal;

the revelation of the most important areas of science and technology which make the greatest contribution for the achievement of the established goals;

the revelation of the most important branches of the economy which guarantee the attainment of the established goals;

the determination of the most effective methods of using the technical means at hand;

the choosing and substantiating of the optimal distribution of resources.

**Method of the Collective Generation of Ideas (Brainstorming)** - a method for the development of creative possibilities for the thinking of experts in order to discover original new ideas on the basis of intuitive thinking and the attainment of a single viewpoint on the problem under study, taking the following rules into account:

an accurate formulation of the essence of the problem and the isolation of the central question;

forbidding declaring any mistaken idea that does not seem to be absolute lunacy;

stimulating the development of every idea, even if its realization is proposed for the distant future;

encouraging participants to support free discussion interrelations, and excluding skepticism during the discussion of any idea.

Collective Expert Evaluation Method - a forecasting method which proposes the determination of the degree of agreement of expert opinions on the concrete prospects for the development of an object. The prospects are formulated earlier by separate specialists (objectivization of opinions). The method proposes the evaluation of several aspects of development on the basis of:

the ensuring of the mutual independence of the opinions of the experts;

the conversion of the evaluations into collective form;

the indication by the experts of the structure of the arguments, serving as the basis for the evaluation;

the indication by the experts of their degree of familiarity with the area to which the evaluation being formed belongs.

**Least Squares Method** - a method for finding correlational or regressive dependence parameters, consisting in the minimization of the sum of quadratic variations between observable quantities and corresponding evaluations (computer values) calculated according to an adapted coupling equation.

**Method of Envelopes** - a method of forecasting the development of technological objects or systems on the basis of graphical-analytic analysis of the evolution of their characteristics, obtained by the construction of an envelope of the general progressive tendency of development of the technological object.

**Method, Based on the Evaluation of the Engineering-Technical Significance of Inventions** - a method of forecasting the development of a branch of technology with the aid of:

a quantitative expression of the engineering-technical significance of the individual patent;

determination of the prospects for the use of the invention in industry and the expediency of patenting it abroad;

reduction of the patents to a comparable form and the analysis of concurrent groups of patents.

**Method, Based on the Theoretical-Informational Analysis of Patents** - a method of forecasting technology by the identification of attributes in the patent file studied, and by the calculation of the integral characteristic--the capacity coefficient of the patent.



**Method of Forecasting on the Basis of Correlational and Regression Models** - a mathematical-statistical method for determining the value of variables beyond the limits of the initial statistical sequence. A method of forecasting scientific-technical progress based on the qualitative/quantitative analysis of the dynamics of issuing patents--a procedure for the extrapolation of tendencies revealed during the analysis of the dynamics of patenting.

**Heuristic Forecasting Method** - a method of obtaining and of the specialized processing of forecast evaluations of an object by means of the systematized interrogation of highly qualified specialists (experts) using heuristic procedures in the process of working out the forecasts, with the goal of synthesizing the obtained results in forecast models.

**Morphological Analysis** - a method of forecasting, based on the revelation of probable alternatives for the development of the object by means of differentiation of the object into the functional elements, physical/chemical components and effects in which the elements are realized, with a subsequent combined analysis and synthesis of elements and components.

**Scientific Measuring Methods of Forecasting** - methods of forecasting quantitative indices for the development of science (number of publications, scholars, number of times works are cited, etc.) on the basis of statistical studies.

**Forecasting on the Basis of Historical, Logical Analysis** - a method of forecasting the development of science and technology by means of the study of the rearrangement of the structure of the thesaurus (nominative, functional and adequate).

**Net Methods of Forecasting** - determining the time for and the probability of the fulfillment of a certain task in a sequence of interconnected tasks, presented in the form of a net.

**Forecasting of the Basis of Theories of Operations Research** - a method of determining the results of sequential actions directed toward the attainment of a goal; a study of operations is carried out in systems which do not allow experiments, and consists in the study of goals, in the determination of initial data and of the time necessary for obtaining it, in the formalized representation of a problem, in determining methods of problem-solving and in the analysis of operation results.

**Forecasting on the Basis of Decision-Making Theory** - a method of determining the strategy of a forecaster on the basis of an accepted system of preferences under conditions of a situation of indeterminateness.

**Forecasting a Branch of Technology on the Basis of Qualitative/Quantitative Analysis of Patents** - a method of determining the level of a technical invention, the breadth of the problem lying at the base of the invention, the complexity of the invention, and the demand for it.

**Regression Analysis** - a method of mathematical statistics which studies the connections between phenomena by the fulfillment of the seven conditions (all except the first) of correlational analysis.

**Regression connections** - a connection between a random and a non-random value.

**Krest System** - a method of determining the applicability of NIR and OKR results for forecasting and planning armament systems.

**Pattern System** - a method of forecasting and planning with the aid of a quantitative evaluation of scientific/technical developments. It includes: the development of a scenario of long-term scientific-technical and socio-economic tendencies, the construction of a tree of goals, the determination of the relative importance of goals and problems, the morphological calculation of problems, the determination of the mutual usefulness of NIR and OKR results, and the determination of the time required for and the probabilities of the solution of concrete scientific/technical problems.

**System of Structurally Temporary Maps** - a means for the fixing and logical analysis of the facts accumulated by mankind represented in a triaxial system: time, structure (classificational) and space (geometric).

**"Forecast" System** - a method of working out long-term forecasts for the development of science and technology and the application of scientific achievements for military purposes.

**"Score" System** - a method of inducing agreement between the long-term (10-15 year) goals of a company with the system of measures ensuring their attainment.

**"Profile" System** - a method of long-term forecasting and NIR planning in research laboratories.

"Feim" System - an automated system for the control of scientific research and developments on the basis of operations forecasts.

TsPO System - a method of long-term planning and NIR, OKR control based on: NIR and OKR classification and on the obtaining of accurate variants of the scientific/technical strategy for the examination and the making of decisions; on the establishment of logical relations between all stages, equations and elements of the decision-making process; on quantitative evaluation of different alternatives for their comparison and selection.

Content (Semantic) Analysis - a method of forecasting based on the qualitative analysis of the evolution of an object, consisting in the sequential examination of alternatives for the development of the object under different combinations of factors which exert influence upon it.

Method of Forecasting on the Basis of Deductive Conclusions - a logical method of making a deduction on the basis of the rules: everything that is asserted about the entire class of elements is asserted about each element included in this class.

Method of Forecasting on the Basis of Inductive Conclusions - a logical method of making a deduction on the basis of the rule: if it is known that a number possesses a property A, and the presence of quality A in a natural number N demands the presence of the quality in a natural number  $N + 1$ , then each natural number possesses a property A. This is mathematical induction. An inductive logical inference is a conclusion about a class of elements as a whole on the basis of the examination of all elements of this class.

Method of Forecasting by Analogy - a logical method of transferring conclusions relative to the presence of an attribute 0 in element A to element B on the basis of establishing a similarity of elements A and B in relation to attribute P.

Scenario - a method of establishing a logical sequence of events with the goal of determining alternatives for the development of large systems like international relations, the economy of nations, areas of science and technology, etc.

Factor Analysis - one of the methods of multivariate statistics. The basic goal: the analysis of the possibilities for discarding part of the variables in a multivariate description of the object or model. Or: the replacement of these variables by a smaller number of certain functions of them, thereby preserving all information about the object.

Extrapolation - a procedure for establishing the value of a function  $f(x)$  for points  $x$ , lying outside an interval with known values of the function at points  $x_0 < x_1 < \dots < x_n$ , lying within the interval  $[x_0, x_n]$ . The accuracy of extrapolation is determined by the same conditions as is that of interpolation.